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DOSES RECEIVED BY PATIENTS AS INDICATOR OF EXPOSURE CONDITIONS: A SURVEY AT TEN HOSPITALS IN JAVA*

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ABSTRACT

DOSES RECEIVED BY PATIENTS AS INDICATOR OF EXPOSURE CONDITION: A SURVEY AT TEN HOSPITALS IN JAVA. Diagnostic radiology procedures were not always done or supervised by qualified operator or radiologist. These situations could probably affect the patients' doses. Indirect assessment of routine exposure condition applied in practices of diagnostic radiology in a hospital was sometimes very useful. One method is done through the measurements of skin dose D_s , the exit dose D_{ex}, and the apparent gonad dose D_g, received by patients undergone thoracic diagnostic radiology procedures. The doses were measured using lithium fluoride thermoluminesence dosemeters (TLD-100) by putting the first and second dosemeter on patient's chest and back respectively, while the third dosemeter was put about 25 cm below the first one. Data were obtained from 1437 patients at various hospitals in Java. Among them, 753 experienced full radiographic procedures, 295 mini radiographic procedures, and 389 fluoroscopic procedures. The use of X-ray tube with the voltage lower than 70 kV combined with no filter condition would yield higher D_s/D_{ex} compared to that using higher voltage technique combined with the use of appropriate filter. Exposure using wide field radiation beam would yield low D_s/D_g compared to that using small one.

Key words: radiology, patient dose, thermoluminesence dosimeters

ABSTRAK

DOSIS PASIEN SEBAGAI INDIKATOR KONDISI PAPARAN: SURVAI DI SEPULUH RUMAH SAKIT DI JAWA. Prosedur radiologi diagnostik tidak selalu dilaksanakan oleh operator yang berkualifikasi atau di bawah pengawasan ahli radiologi. Keadaan seperti ini mungkin berpengaruh pada terimaan dosis pasien. Penetapan tidak langsung kondisi paparan rutin yang diterapkan dalam praktek radiologi diagnostik di rumah sakit kadang-kadang sangat bermanfaat. Salah satu cara pelaksanaannya adalah melalui pengukuran dosis kulit D_s , dosis tempat berkas keluar dari pasien D_{ex} , dan dosis pada arah berkas menuju gonad D_g yang diterima pasien yang mendapat pemeriksaan radiografi thoraks. Terimaan dosis ini diukur menggunakan dosimeter termoluminesensi (DTL 100) yang masing-masing ditempelkan pada punggung dan dada pasien, dan yang ketiga ditempelkan 25 cm di bawah dosimeter pertama. Diperoleh data dari 1437 pasien dari berbagai rumah sakit di Jawa. Di antaranya 753 pasien yang mendapat pemeriksaan radiografi penuh, 295 mendapat pemeriksaan radiografi mini (MCS), dan 389 mengalami pemeriksaan fluoroskopi. Pemakaian tabung sinar-X dengan tegangan di bawah 70 kV dan tanpa dipasang filter tambahan, menghasilkan D_s /D_{ex} lebih tinggi dibandingkan dengan yang menggunakan teknik tegangan lebih tinggi ditambah dengan pemasangan filter. Pemberian paparan dengan berkas radiasi yang terlalu luas menghasilkan D_s /D_g yang rendah di bandingkan dengan luas berkas yang lebih kecil.

Kata kunci: radiologi, dosis pasien, dosimeter termoluminesensi

INTRODUCTION

Ionizing radiation is one of the sources of risk naturally present in the living environment. Risk coming from ionizing radiation may change when man made radiation is received by man significantly. Radiotherapy procedure may reduce the risk of the patient from secondary cancer, but stray X-ray originating from diagnostic radiology practices may enhance risk to patient that is not yet fully recovered from serious illness.

Biological effect from normal low doses given during X-ray diagnostic procedure is not significant individually. However, if there are a large number of people involved in this kind of procedure, public risk can be very significant. The frequency of fatal cancers occurred in a society will proportionally depends on the man-sievert in the society. This frequency can be reduced either by reducing the number of individual undergoing X-ray diagnostic procedure or by reducing the individual dose given to the patient. Every negligence done today has to be paid by the later generation. Keane and Tikhonov[3] wrote "Radiologist should therefore be aware of their responsibilities" to the human race. In their everyday work they should bear three facts constantly in mind:

The number of mutagenic factors in our environment and daily life is unknown but certainly increasing; ionizing radiation is, however, the one best known and perhaps the most serious concerning mutagenic capacity. The benefit to the individual of X-ray investigations, which counter balances the small somatic-stochastic risk, is not a benefit to the unborn. X-ray diagnosis is at present the major contributor of man made radiation exposure of most populations. Due to stochastic effect that might occur in the society, it is important to reduce the doses coming from medical exposure, and to limit the number of individual undergoing radiological diagnostic procedure. Therefore, wherever there is an alternate, for the sake of well being of patient and society, the consideration should be taken seriously.

Once the decision of applying radiological diagnostic procedure is taken, the main interest has to be aimed to get the best information required. However, the specialist should bear in his or her mind not to neglect the risk of the patient due to the doses received during the procedure. Therefore, we should take the best available techniques of exposure. Unfortunately, the execution of diagnostic radiology procedures was not always done by or supervised by a qualified radiographer or a radiologist. The main objective of this paper is to show the possiblity of the measurements of dose received by patients as a method for evaluating technique of exposure applied at various health centre .

HYPOTHESIS

In radiography normally we use film as detector. Depending on the type of the film, the latent image formations require a certain amount of minimum dose. This minimum dose is the exit dose, D_{ex}. The exit dose is due to the primary beam that is

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not interact with the tissue and then leaving the patient, and of course some scattered beam.

X-ray beam used in diagnostic procedure is normally comprise of wide spectrum dominated by low energy component. Increasingly low energy component will be found if the beam is produced by X-ray tube operated at low voltage and emerge unfiltered. The tissue will absorbs more of this low energy component of the beam, causing only very small fraction of the beam emerging from the patient's body and exposing the film. Trout et al in Johns[2] shows 0.7% of the beam produced in 85 kV tube and filtered by 1 mm Al and passing 20 cm object, will reach the film. This low percentage of the emerging beam will improve to 1.7% if it is filtered by 3 mm Al. The qualities of the beam that is depend on several factors such as kV, filter used combined with exposure condition can be indicated by D_s / D_{ex}. The high value of D_s / D_{ex} indicates the use of poor beam quality due to low tube voltage and/or not applying sufficient filter. In the other hand the low values of D_s / D_{ex} indicate the use of good quality beam, either by applying higher tube voltage and/or sufficient filter.

The unnecessary exposure should be avoided in any case. This can be done using correct size of field. In thoracic radiography the use of too large field will expose gonad unnecessarily. In this case the use of field can be evaluated through the value of D_s / D_g. D_g is the dose on the surface of skin, at a point past by the line drawn from the focus to the gonad. The high value of D_s / D_g indicating the use of relatively small field, or the beam is directed slightly upward; the low value of $D_s /_g$, in the other hand, indicating the use of relatively bigger field, or the direction of the beam is slightly downward.

The patients' dose data, as indicated earlier, may indicate "habit of practice" in the Radiology Department of a health centre. The high D_s shows the use of excessive tube current, or the use of too low tube voltage combined with less sufficient filter thickness, or the mAs applied is large. When D_s is high, but the D_{ex} is low causing high value of D_s/D_{ex}, the tube voltage may be too low and used without applying appropriate filter. When D_s is high while the value of D_s/D_{ex} is low, the exposure is possibly given by applying high voltage technique combined with appropriate filter, but long exposure time (large mAs). In the other hand, when D_s/D_{ex} is high while the D_k is low, the exposure might be executed applying low voltage technique, and no filter used, and short exposure time. The last possibility we can find is the low value of both D_s and D_s/D_{ex}. The latest situations indicate of the application of high voltage technique combined with sufficient filter, and low mAs. The latest is considered to be the most appropriate technique; the situation may be even better if combined with the use of sensitive film or fluoroscopic screen.

In fluoroscopy technique, the minimum exposure required to form a good quality radiological picture is essential. It is much dependent on the sensitivity of the fluoroscopic screen, the image intensifier, the condition of the dark room where the fluoroscopy performed, and the adaptation period to the darkness adopted by the radiologist. Good procedure will result both in low D_s and D_s/D_{ex}, and of course a good quality radiological image.

METHODOLOGY

In this survey, the dose at the surface of the skin of patients undergoing thoracic posterior-arterior (PA) diagnostic radiology procedure were measured. For this purpose, three positions at the surface of the body have been selected. First, a set of TL dosemeter put at a point on the back of patient will represent D_s. The point passed by the symmetrical axis of the incidence beam was at the back of the patient. Second, TL dosemeter put at a point on the chest and passed by the axis of the emerging beam will represent D_{ex}. The third, a set of TL dosemeter were put at a point approximately 25 cm below the first set. The dose recorded by the third set of dosemeter will represent D_g. Full size radiography, mini radiography (MCS), and

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fluoroscopy were selected in the survey. Data obtained from each institution were averaged for the total number of patients in each type of procedure. These averaged data were used to evaluate "the habit of practice" in each institution.

The dosemeter used were of Harshaw TLD-100 in the "chip" form. Dosemeter having sensitivity deviation within ± 5% were considered as having one calibration factor.

ANALYSIS

In the survey, data of doses of 1437 patients, from ten health centres operating in Java Island were obtained. Among them, 753 patient experiencing full radiography procedure, 295 exposed by MCS technique, and 389 diagnosed fluoroscopically. Table 1 shows the data of doses received by patients at the various health centres. Table 2 and 3 show the technique and it's related doses.

According to Huxter[1] in the thoracic radiography technique applying 60-75 kV under normal procedure and using the latest very sensitive photographic film, gave the patients' skin dose (D_k) of 40 to 100 mR. These values were not considered as the best, but reflected the average condition of exposure only. If the higher voltage technique was applied, the value of D_s would decrease.

Among the ten institutions surveyed, six of them that practicing radiography technique indicating relatively high D_s found at two institutions (Institution no II and X). Four institutions give relatively high D_s/D_{ex}.

Informations given by the participating institutions indicated that most of the practice applying not higher than 70 kV voltage. Due to the less penetrating power of the beam, it tend to push the operator applying high tube current, e.g. up to 200 mA or even higher, resulting in high D_s/D_{ex}. One institution indicating very low D_s/D_{ex}, it was found that it was due to high value of D_{ex} required to obtained good radiographs. The high value of D_s/D_g reflects the use of relatively good ajusted field.

References

[1] HUXTER, E. A. "*Teknik Memotret Roentgen*" Sombu Pilay, penerjemah, Siemen erlangen, 1973.

[2] JOHNS, H. E.,"*The Physics of Radiology*", 2 nd ed., 3rd printing, Charles C. Thomas Publ., USA,1966.

[3] KEANE and TIKHONOV,"*Manual of Radiation Protection in Hospital and General Practice*", IAEA & WHO, 3, 85

Table 1. Exposure (mR) from diagnostic radiology procedure in various health centres

Institute / Exposure		I	II	III	IV	V	VI	VII	VIII	IX	X
D_s	R	31.74	64.54	34.77	39.94	-	-	-	-	-	-
	F	-	-	-	493..98	137.23	155.14	410.88	32.46	32.24	48.51
D_{ex}	R	7.73	12.84	7.57	33.09	-	-	-	-	-	-
	F	-	-	-	22.38	9.68	9.46	12.15	8.34	11.96	11.61
D_g	R	15.80	33.75	35.22	50.97	-	-	-	-	-	-
	F	-	-	-	30.58	11.31	11.40	15.35	22.10	19.03	15.90
D_s/D_{ex}	R	4.11	5.03	4.59	1.21	-	-	-	-	-	-
	M	12.04	-	-	-	-	-	-	-	-	-
	F	-	-	-	22.07	14.18	16.40	33.82	3.89	2.70	4.18
D_s/D_g	R	2.01	1.91	0.99	0.95	-	-	-	-	-	-
	M	2.60	-	-	-	-	-	-	-	-	-
	F	-	-	-	16.15	12.13	13.61	26.77	1.47	1.69	3.05

R - radiography
M - mini radiography (MCS)
F - fluoroscopy

Table 2. Tube voltage (kV) and current (mA) applied at the various institutions. and its related exposure (mR) to patients for radiographic technique

Inst.	D_s	ΔD_s*	D_{ek}	ΔD_{ex}*	kV	mA	D_s/D_{ex}	Filter mm Al.
II	64.54	+27.57	12.84	- 0.03	L	H	5	1
X	48.51	+11.54	11.61	- 1.26	L-H	M	4.2	1
IV	39.94	+ 2.97	33.09	+20.2	M	H	1.2	2
III	32.24	- 2.20	7.57	- 5.30	L	H	4.6	3
IX	32.24	- 4.73	11.96	- 0.91	L	L	2.7	-
I	31.74	-5.23	7.73	- 5.14	L	M-H	4.1	0.3/0.25

* Relative to the average of the total
kV : L < 70; 70 < M < 100 ; H > 100
mA : L < 50 ; 50 < M < 100 ; H > 100

Table 3. Tube voltage (kV) and current (mA) applied at the various institutions. and its related exposure (mR) to patients for fluoroscopic technique

Inst.	D_s	ΔD_s*	D_{ek}	ΔD_{ex}*	kV	mA	D_s/D_{ex}	Filter mm Al.
IV	493.98	+201.57	22.38	+ 7.95	M	H	22.07	-
VII	410.88	+118.47	12.15	- 2.28	-	-	33.82	1
VI	155.14	-137.27	9.46	- 4.97	-	-	16.40	-
V	137.23	-155.18	9.68	- 4.75	L	-	14.18	-
VIII	32.46	-259.95	8.34	- 6.09	L	L	3.89	1

* Relative to the average of the total
kV : L < 70; 70 < M < 100 ; H > 100
mA : L < 50 ; 50 < M < 100 ; H > 100
- : unknown